Chapter 2:

Electrostatic Fields

❖ Introduction to Electrostatics :

- **Produced by : Charge at rest and invarying of time.**

- **Models:**

$$\text{equations}\begin{cases} \text{rot}\,\vec{E} = 0 \\ \text{div}\,\vec{D} = \rho_v \end{cases}$$

$$\text{B.C}\begin{cases} E_{1t} - E_{2t} = 0 \\ D_{1n} - D_{2n} = \rho_S \end{cases}$$

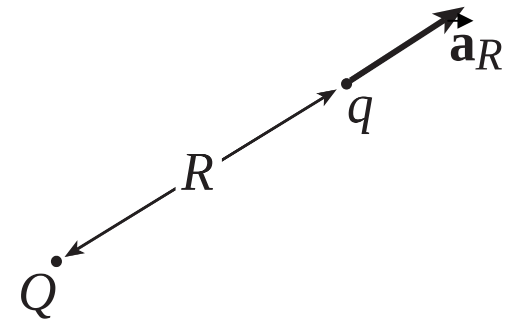
And : $\vec{D} = \varepsilon\vec{E} = \varepsilon_r \varepsilon_0 \vec{E}$

2.1: Coulomb Law and Superposition :

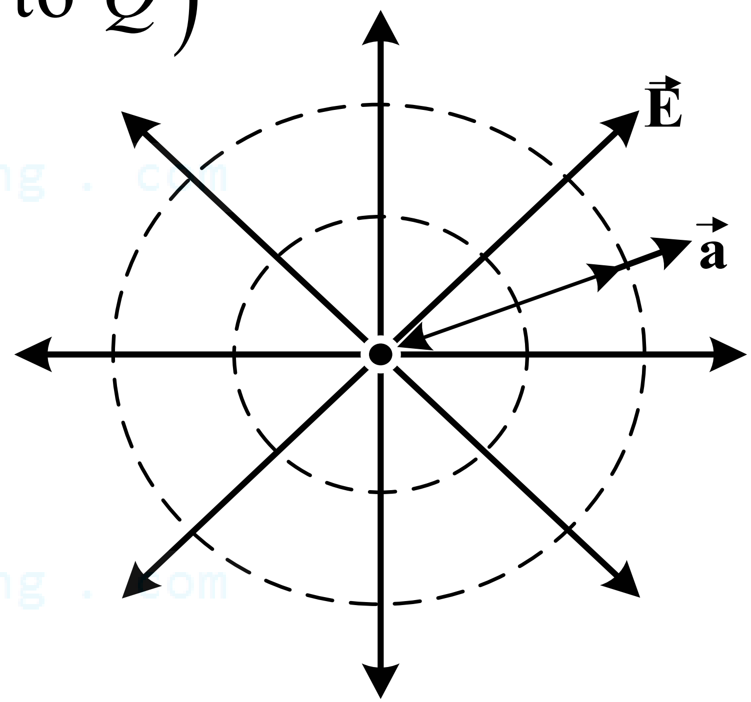
a) Electric Field of a Point Charge:

$$\vec{\mathbf{F}}_e = \frac{Qq}{4\pi\varepsilon R^2}\vec{\mathbf{a}}_R \quad \text{(Coulomb's Law)}$$

$$= q\left(\frac{Q}{4\pi\varepsilon R^2}\vec{\mathbf{a}}_R\right) = q\left(\vec{\mathbf{E}} \text{ due to } Q\right)$$



$$\vec{\mathbf{E}} \text{ due to } Q = \frac{Q}{4\pi\varepsilon R^2}\vec{\mathbf{a}}_R$$

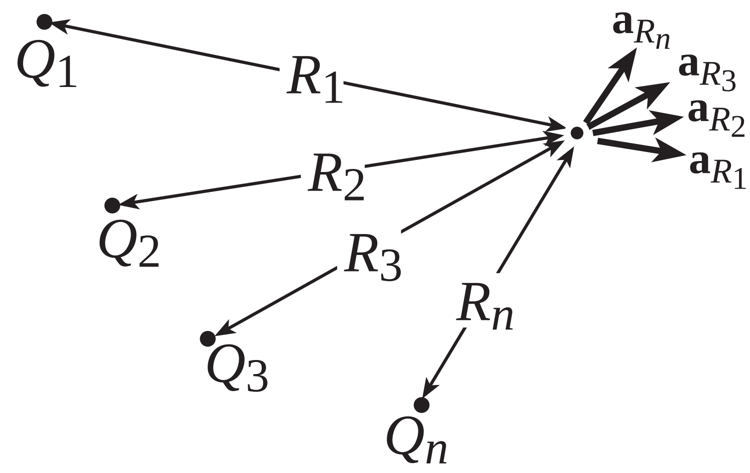


Constant magnitude surfaces are spheres centered at Q. Direction lines are radial lines emanating from Q.

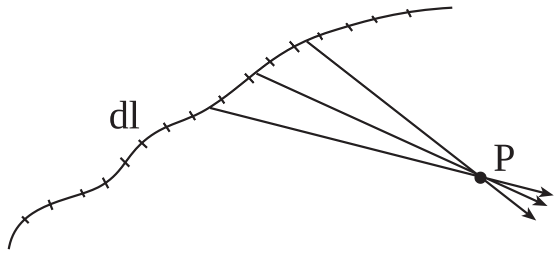
b) $\vec{E}$ due to Collection of point charges :

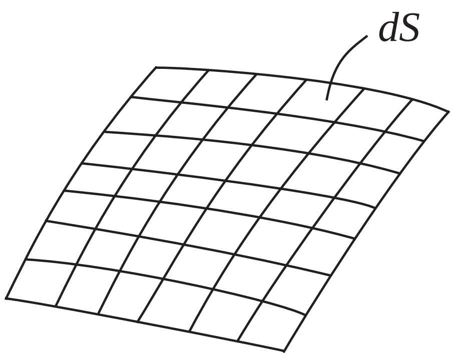
Superposition :

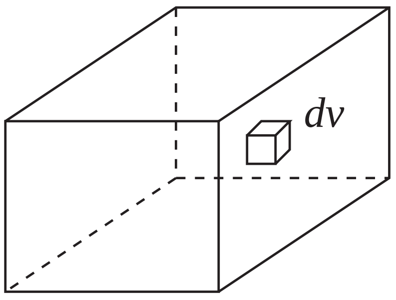
$$\vec{E} = \sum_{j=1}^{n} \frac{Q_j}{4\pi\varepsilon R_j^2}\vec{a}_{Rj}$$



c) $\vec{E}$ due to charge distributions :







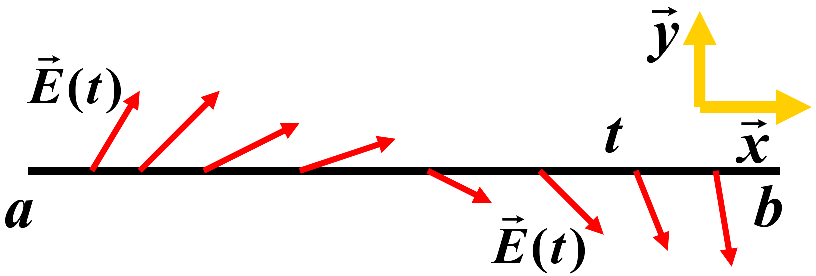
Differential Charge : $\mathbf{dq} = \begin{cases} \rho_L d\ell \\ \rho_S dS \\ \rho_V dV \end{cases}$

$$\vec{\mathbf{E}} = \int_{L,S,V} \frac{dq}{4\pi\varepsilon R^2}\vec{\mathbf{a}}_R = \int_{L,S,V} \frac{dq}{4\pi\varepsilon R^3}\vec{\mathbf{R}}$$

❖ Find the electric field: values of Vector Integrals ?

Integrals containing vector functions

$$\int_a^b \vec{E}(t)dt$$



How can we find the values of such integrals?

$\int_a^b \vec{E}(t)dt$ **- this is the vector, so we can calculate each component of this vector**

We can write $\vec{E}(t) = E_1(t)\vec{x} + E_2(t)\vec{y}$ **, where only scalar functions** $E_1(t), E_2(t)$ **depend on** ***t*****, but not the basis vectors** $\vec{x}, \vec{y}$ **.**

Then the integral takes the form

$$\int_a^b \vec{E}(t)dt = \vec{x}\int_a^b E_1(t)dt + \vec{y}\int_a^b E_2(t)dt$$

so now there are two integrals which contain only scalar functions